

Then invention will now be further described by the following numbered paragraphs:

1. A polypeptide monomer capable of oligomerisation, said monomer comprising an heterologous amino acid or amino acid sequence inserted into the sequence of a subunit of an oligomerisable protein scaffold.
2. A polypeptide monomer according to paragraph 1, wherein the oligomerisable protein scaffold subunit is selected from the group consisting of bacteriophage T4 Gp31, Escherichia coli GroES and homologues thereof of the cpn10 family, and Escherichia coli GroEL and homologues thereof of the cpn60 family.
3. A polypeptide monomer according to paragraph 1 or paragraph 2, wherein the heterologous amino acid or amino acid sequence is inserted into the sequence of the oligomerisable protein scaffold subunit such that both the N and C termini of the polypeptide monomer are formed by the sequence of the oligomerisable protein scaffold subunit.
4. A polypeptide monomer according to any preceding paragraph, wherein the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by replacing one or more amino acids thereof.
5. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by substantially replacing the mobile loop between amino acid positions 23 and 44.
6. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by substantially replacing the mobile loop between amino acid positions 15 and 34.
7. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and the heterologous amino acid or amino acid sequence is inserted between positions 54 and 67 of the oligomerisable protein scaffold subunit.

8. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and the heterologous amino acid or amino acid sequence is inserted between positions 43 and 63 of the oligomerisable protein scaffold subunit.
9. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and heterologous amino acids or amino acid sequences are inserted at both positions described in paragraphs 5 and 7.
10. A polypeptide monomer according to paragraph 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and heterologous amino acids or amino acid sequences are inserted at both positions described in paragraphs 6 and 8.
11. A polypeptide monomer according to paragraph 2, wherein the heterologous amino acid sequence is displayed at the N or C terminus of the oligomerisable protein scaffold subunit.
12. A polypeptide oligomer comprising two or more polypeptide monomers according to any preceding paragraph.
13. A polypeptide oligomer according to paragraph 12, which is a homooligomer.
14. A polypeptide oligomer according to paragraph 12, which is a heterooligomer.
15. A polypeptide oligomer according to paragraph 14, wherein complementary biological activities are juxtaposed through the oligomerisation of different polypeptide monomers.
16. A polypeptide oligomer according to any one of paragraphs 12 to 15, wherein the monomers are covalently crosslinked.
17. A polypeptide oligomer according to any one of paragraphs 12 to 16, wherein the protein scaffold is in the form of a ring.

18. A polypeptide oligomer according to paragraph 17, wherein the ring is a heptameric ring.
19. A polypeptide monomer or oligomer according to any preceding paragraph, wherein the heterologous amino acid sequence is an immunogen.
20. A polypeptide oligomer or monomer according to paragraph 19, wherein the protein scaffold is bacterial or bacteriophage in origin.
21. A polypeptide according to paragraph 19 or paragraph 20, for use in the detection or neutralisation of antibodies in vivo.
22. Use of a polypeptide according to paragraph 19 or paragraph 20 for the detection or neutralisation of antibodies in vitro.
23. A polypeptide according to paragraph 19 or paragraph 20, for use as a vaccine.
24. A polypeptide monomer or oligomer according to any one of paragraphs 1 to 18, wherein the heterologous amino acid sequence is an antibody or an antigen-binding fragment thereof.
25. A polypeptide according to paragraph 24, wherein the antibody fragment is a natural or camelised VH domain.
26. A polypeptide according to paragraph 25, wherein the antibody fragment is a VH CDR3.
27. A polypeptide according to any one of paragraphs 24 to 26, for use in the detection or neutralisation of antigens in vivo.
28. Use of a polypeptide according to any one of paragraphs 24 to 26 for the detection or neutralisation of antigens in vitro.

29. A polypeptide monomer or oligomer according to any one of paragraphs 1 to 18, wherein the heterologous amino acid sequence is a ligand for a receptor.
30. A polypeptide monomer or oligomer according to any one of paragraphs 1 to 18, wherein the heterologous amino acid sequence is a substrate for a kinase or phosphatase.
31. A polypeptide according to paragraph 29 or paragraph 30, wherein the heterologous amino acid sequence comprises an at least partly randomised portion.
32. A polypeptide monomer or oligomer according to any one of paragraphs 1 to 18, wherein the heterologous amino acid sequence is capable of mediating a biological activity.
33. A polypeptide according to paragraph 32, wherein the heterologous amino acid sequence is selected from the group consisting of an enzyme, an antibiotic, an enzyme inhibitor, a molecule involved in cell signalling, a hormone, an antigen, an immunogen, a nuclear localisation sequence, a cellular uptake sequence, a DNA binding sequence, a solid surface binding sequence composed of random charged amino acids, a receptor and a ligand for a receptor.
34. A polypeptide oligomer according to paragraph 32 or 33, which comprises two or more different heterologous amino acid sequences having different biological activities.
35. A nucleic acid sequence encoding a polypeptide according to any preceding paragraph.
36. A method for preparing a polypeptide according to any one of paragraphs 1 to 35, comprising the steps of inserting a nucleic acid sequence encoding a heterologous polypeptide into a nucleic acid sequence encoding a subunit of an oligomerisable protein scaffold, incorporating the resulting nucleic acid into an expression vector, and expressing the nucleic acid to produce the polypeptide monomers.

Claims

1. A polypeptide monomer capable of oligomerisation, said monomer comprising an heterologous amino acid or amino acid sequence inserted into the sequence of a subunit of an oligomerisable protein scaffold.
2. A polypeptide monomer according to claim 1, wherein the oligomerisable protein scaffold subunit is selected from the group consisting of bacteriophage T4 Gp31, Escherichia coli GroES and homologues thereof of the cpn10 family, and Escherichia coli GroEL and homologues thereof of the cpn60 family.
3. A polypeptide monomer according to claim 1, wherein the heterologous amino acid or amino acid sequence is inserted into the sequence of the oligomerisable protein scaffold subunit such that both the N and C termini of the polypeptide monomer are formed by the sequence of the oligomerisable protein scaffold subunit.
4. A polypeptide monomer according to claim 1, wherein the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by replacing one or more amino acids thereof.
5. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by substantially replacing the mobile loop between amino acid positions 23 and 44.
6. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and the heterologous amino acid or amino acid sequence is inserted into the oligomerisable protein scaffold subunit by substantially replacing the mobile loop between amino acid positions 15 and 34.
7. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and the heterologous amino acid or amino acid sequence is inserted between positions 54 and 67 of the oligomerisable protein scaffold subunit.

8. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and the heterologous amino acid or amino acid sequence is inserted between positions 43 and 63 of the oligomerisable protein scaffold subunit.
9. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is bacteriophage T4 Gp31 and heterologous amino acids or amino acid sequences are inserted between positions 23 and 44 and 54 and 67.
10. A polypeptide monomer according to claim 4, wherein the oligomerisable protein scaffold subunit is Escherichia coli GroES and heterologous amino acids or amino acid sequences are inserted between positions 15 and 34 and 43 and 63.
11. A polypeptide monomer according to claim 2, wherein the heterologous amino acid sequence is displayed at the N or C terminus of the oligomerisable protein scaffold subunit.
12. A polypeptide oligomer comprising two or more polypeptide monomers according to claim 1.
13. A polypeptide oligomer according to claim 12, which is a homooligomer.
14. A polypeptide oligomer according to claim 12, which is a heterooligomer.
15. A polypeptide oligomer according to claim 14, wherein complementary biological activities are juxtaposed through the oligomerisation of different polypeptide monomers.
16. A polypeptide oligomer according to claim 12, wherein the monomers are covalently crosslinked.
17. A polypeptide oligomer according to claim 12, wherein the protein scaffold is in the form of a ring.
18. A polypeptide oligomer according to claim 17, wherein the ring is a heptameric ring.

19. A polypeptide monomer or oligomer according to claim 1, wherein the heterologous amino acid sequence is an immunogen.
20. A polypeptide oligomer or monomer according to claim 19, wherein the protein scaffold is bacterial or bacteriophage in origin.
21. A polypeptide according to claim 19, for use in the detection or neutralisation of antibodies in vivo.
22. Use of a polypeptide according to claim 19 for the detection or neutralisation of antibodies in vitro.
23. A polypeptide according to claim 19, for use as a vaccine.
24. A polypeptide monomer or oligomer according to claim 1, wherein the heterologous amino acid sequence is an antibody or an antigen-binding fragment thereof.
25. A polypeptide according to claim 24, wherein the antibody fragment is a natural or camelised VH domain.
26. A polypeptide according to claim 25, wherein the antibody fragment is a VH CDR3.
27. A polypeptide according to claim 24, for use in the detection or neutralisation of antigens in vivo.
28. Use of a polypeptide according to claim 24, for the detection or neutralisation of antigens in vitro.
29. A polypeptide monomer or oligomer according to claim 1, wherein the heterologous amino acid sequence is a ligand for a receptor.
30. A polypeptide monomer or oligomer according to claim 1, wherein the heterologous amino acid sequence is a substrate for a kinase or phosphatase.

31. A polypeptide according to claim 29, wherein the heterologous amino acid sequence comprises an at least partly randomised portion.
32. A polypeptide monomer or oligomer according to claim 1, wherein the heterologous amino acid sequence is capable of mediating a biological activity.
33. A polypeptide according to claim 32, wherein the heterologous amino acid sequence is selected from the group consisting of an enzyme, an antibiotic, an enzyme inhibitor, a molecule involved in cell signalling, a hormone, an antigen, an immunogen, a nuclear localisation sequence, a cellular uptake sequence, a DNA binding sequence, a solid surface binding sequence composed of random charged amino acids, a receptor and a ligand for a receptor.
34. A polypeptide oligomer according to claim 32, which comprises two or more different heterologous amino acid sequences having different biological activities.
35. A nucleic acid sequence encoding a polypeptide according to claim 1.
36. A method for preparing a polypeptide according to claim 1, comprising the steps of inserting a nucleic acid sequence encoding a heterologous polypeptide into a nucleic acid sequence encoding a subunit of an oligomerisable protein scaffold, incorporating the resulting nucleic acid into an expression vector, and expressing the nucleic acid to produce the polypeptide monomers.